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C-CORE

Data Report

Ocean Drifter Studies Of Surface Currents Along The Coasts Of Newfoundland And Labrador And In The Beaufort Sea

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OCEAN DRIFTER STUDIES OF SURFACE CURRENTS ALONG THE COASTS OF NEWFOUNDLAND AND LABRADOR AND IN THE BEAUFORT SEA

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ABSTRACT

Nine thousand plastic surface drift cards were released off the coast of eastern Canada in 1979 and 1980 at known or proposed oil drilling sites in an attempt to determine the probable extent and landfall of oil which might be accidentally spilled at these sites. A small number of cards were returned from North American locations. All of these were from release sites north of 58°N and constituted less than 1% of the total cards released in this area. The vast majority of the returned cards were found in Europe, primarily Ireland and the U.K.

In addition, 630 cards were released at well sites near the MacKenzie Delta in the Beaufort Sea. Some passed through the Bering Strait and were found in the Aleutian Islands and the west coast of North America, however most, predictably, were swept westward from the release sites and were found along the north and west coasts of Alaska and the N.W.T.

ACKNOWLEDGEMENTS

We gratefully acknowledge the cooperation of the following organizations in the release of the drift cards used in this study: Texaco Canada Inc., Canadian Marine Drilling Ltd., Esso Resources Canada, BP Canada, Mobil Oil Canada, and the Bedford Institute of Oceanography.

Thanks are also due the enormous number of people in Ireland, The United Kingdom, France, Spain, Portugal, Norway, Sweden, Denmark, Belgium, Holland and Germany, as well as Newfoundland, Labrador and the North West Territories, who found our cards and took the time to return them.

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INTRODUCTION

Very little hard data exists with respect to surface currents over the Labrador Shelf (Smith, Soule & Mosby, 1937; Collin & Dunbar, 1964; Ettle & Wolford, 1972; Lazier, 1971). We do know that there is a net southerly flow, however the information is not good enough to reliably predict landfall for a spill 50 to 200 km offshore. Figure 1, after Petrie (1980), indicates the gross current patterns in the area of our releases as they are generally understood. Various, somewhat conflicting reports exist on surface circulations in the Funk Island Bank region and the Grand Banks area exhibits a highly changeable surface current pattern due to mixing in this region of two major water masses with concommitant development of eddies of unpredictable size, longevity and trajectory. The overall movement in this latter area is, in general, easterly.

A drift card release program was undertaken on the northeastern seaboard of Canada and in the Canadian Beaufort during the summer of 1979 and on the Grand Banks of Newfoundland in June 1980. The study was undertaken in an attempt to determine probable oilspill trajectories in the case of a blowout or accidental spill from one of the offshore wellsite locations on the continental shelf. Cards were released from either operating rigs or vessels near known exploration sites through the cooperation of major exploration companies and of the Bedford Institute of Oceanography.

Figure 1. Major surface currents in the region of the Newfoundland/Labrador drift card releases.

Although we will continue to receive sporadic returns for some years to come, the results to date are significant and not likely to change drastically. This is to be considered a final report on the 1979 and 1980 release program.

METHOD

Two seperate drifter experiments were carried out on the east coast during the summer of 1979. A drifter release study was carried out in 1979/80 by the Department of Energy Mines and Resources to test the specific premise that landfall would only occur if a spill occurred during a period of intense onshore wind (Vandall & Bezanson, 1981).

The C-CORE release program was designed on the alternative premise that weather patterns were not sufficiently persistent in the long term to alter appreciably the final destination of surface borne material. Therefore, a release strategy - independent of weather conditions - should have as much chance of producing landfall on Labrador or Newfoundland coastlines as would a selective release strategy. The procedure was therefore to release batches of 500 cards at regular intervals regardless of prevailing wind. (The release data and locations are noted in Table 1 and Figure 2 for the northeastern seaboard).

In the Beaufort Sea, where the release sites were much closer to shore, it was entirely possible for a single day's wind to carry cards ashore. It was considered prudent therefore to release cards on a daily basis in order to generate an average picture of possible trajectories. Batch releases of 10 cards per day from four exploration drillships operating in the Canadian Beaufort were undertaken. [Table 2, Figure 3].

The cards themselves were designed to simulate an oil slick. For this purpose we used a polyethylene card with a density of 0.95. It was the size of a postcard and 0.05 in. (1.3mm) thick

Figure 2. Release sites for the Newfoundland and Labrador surface drifter program.

with sufficient weight that it was unlikely to become airborne in high winds (Figure 5). The card was colorfully inscribed with a return address, request for information from the finder and the promise of a $2.00 reward.

The cards floated in a horizontal attitude presenting a large surface area to wind influence and relatively low drag in the water column as is the case with an oil slick. There was some concern as to direct wind influence on this design. We therefore released one control batch of 50 cards which had been ballasted to float vertically, almost neutrally buoyant with less than 2% of the card above the surface. These weighted cards were released simultaneously with 450 standing cards near the Bjarni wellsite. There was no appreciable difference between the spatial or temporal distributions of landfall, however percentage returns differed considerable between the weighted and unweighted cards in this release. Of the series containing the 50 weighted and the remaining 50 unweighted, only 14% of the weighted cards were returned while 36% of the unweighted ones came back. (See Appendix B(i) - Bjarni releases - for return data for this series number.

Harvey (1968) using a Menai Bridge sea-surface drifter found between 19% and 35% return rates from releases in the Irish Sea while Cunningham (pers.comm.) found return rates as high as 40% for releases of drift bottles off the west coast of Ireland. These are normal return rates for surface drifter releases on the

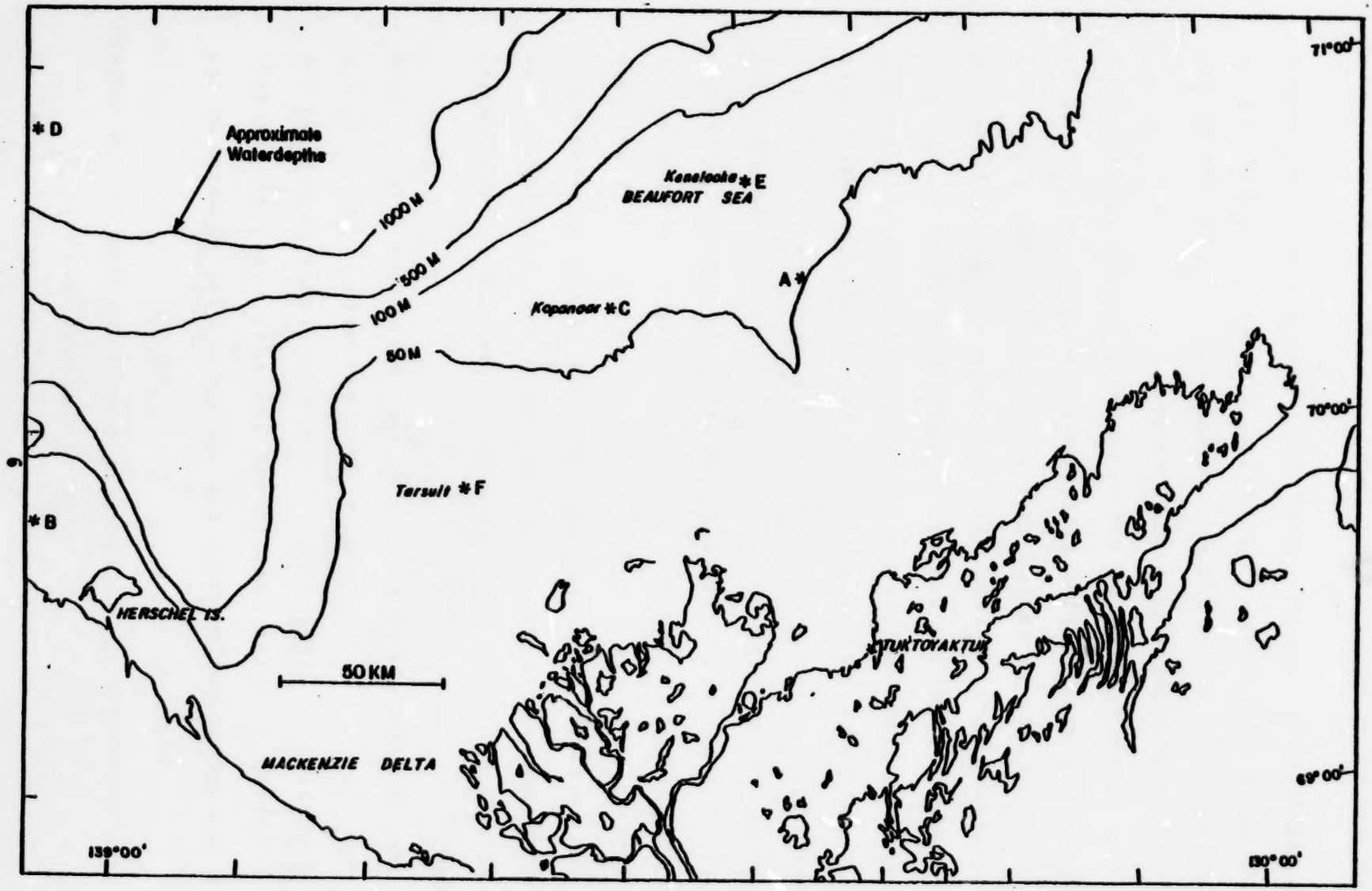


Figure 3. Release sites of drift cards in the Beaufort Sea

Table 1. Release data for drift cards released along the coasts of Newfoundland and Labrador

RELEASE DATE	SERIES NUMBERS	LOCATION	LATITUDE	LONGITUDE
24 AUGUST 1979 31 AUGUST 1979 19 SEPTEMBER 1979	071,086,058,074,079 042,044,073,083,088 059,075,087,089,090	DAVIS STRAIT	62°56'N	59°06'W
19 AUGUST 1979	006-010	SAGLEK BANK (CABOT)	59°48'N	62°51'W
20 AUGUST 1979	011-015	SAGLEK BANK (KARLSTAFNI)	58°53'N	61°45'W
22 AUGUST 1979	016-020	NAIN BANK (SNORRI)	57°20'N	60°20'W
15 AUGUST 1979	001-005	MAKKOVIK BANK (BJARNI)	55°30'N	57°44'W
27 AUGUST 1979	026-030	BELLE ISLE BANK(VERRAZANO)	52°33'N	54°52'W
27 AUGUST 1979 10 SEPTEMBER 1979 24 SEPTEMBER 1979	052,053,055-057 041,050,061,065,072 062-064,066,069	FUNK ISLAND BANK	51°10'N	51°04'W
28 JULY 1970 4 AUGUST 1979	021,022 023,024	FLEMISH PASS	49°18'N	49°37'W
24 JUNE 1980	032,038-040,067 068,078,085,097,099		46°31.34'N	48°24.69'W
25 JUNE 1980	036,045,048,049,051 060,070,080,091,093	GRAND BANKS (HIBERNIA)	46°48.74'N	48°43.94'W
26 JUNE 1980	037,046,047,054,076 077,084,096,098,100		46°41.99'N	48°54.29'W

Table 2. Release Data For Drift Cards Released In The Beaufort Sea

Release Date: September 1979	Release Site A	B	C	D	E	F
10	10	10	10			
11	10	10xx	10			
12	10	10x		10x		
13	10	10			10	
14	10	10			10	
15	10x	10			10	
16	10	10xx			10	
17	10	10			10	
18	10	10			10	
19	10	10			10	
20	10x	10			10	
21	10	10			10	
22	10	10			10	
23	10	10				10
24	10	10x				10
25	10	10x				10
26	10	10				10
27	10xx	10				10
28	10	10				10
29	10	10x				10
30	10	10				10

x = one card returned

Release site designations refer to those noted on Figure 3.

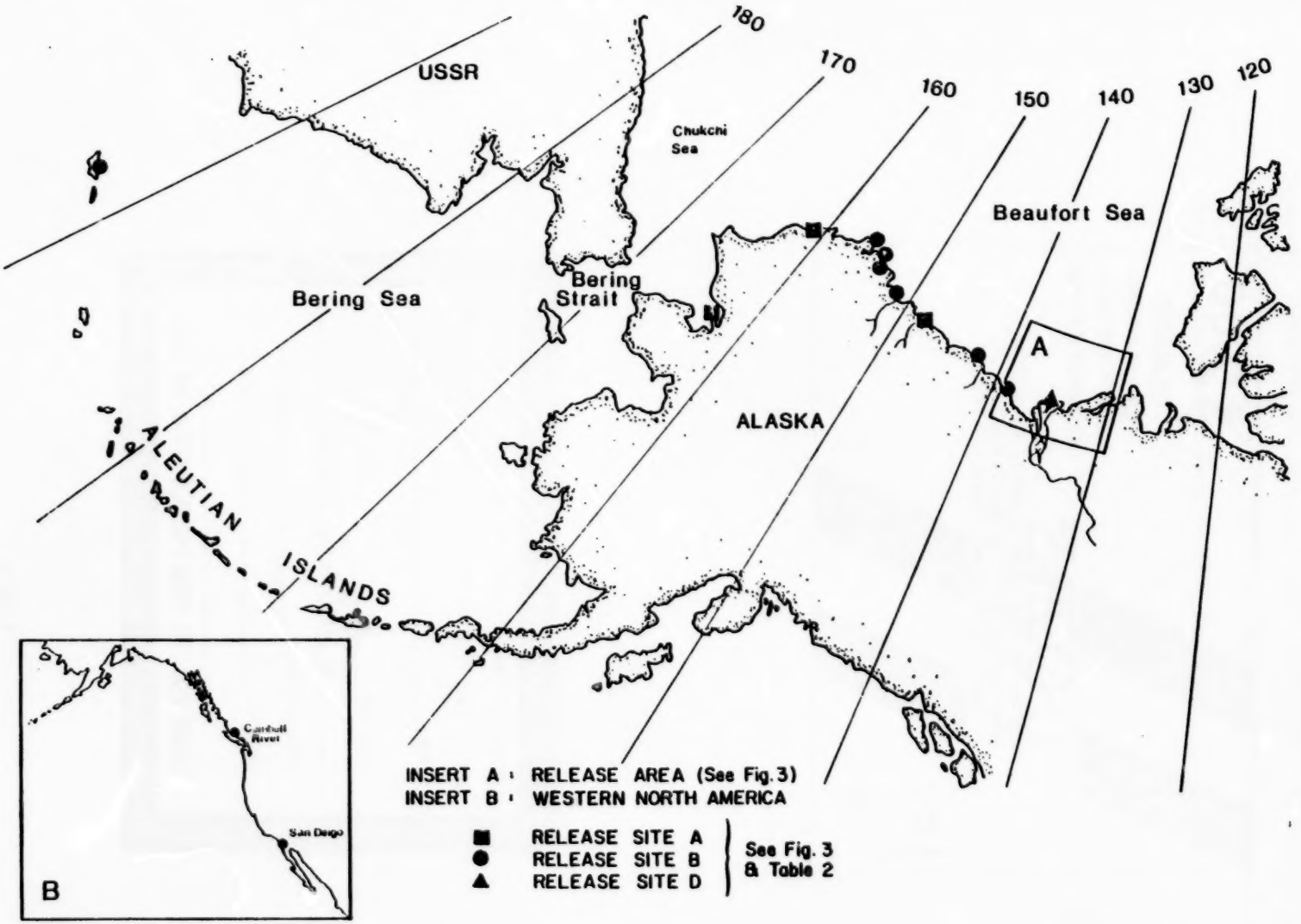
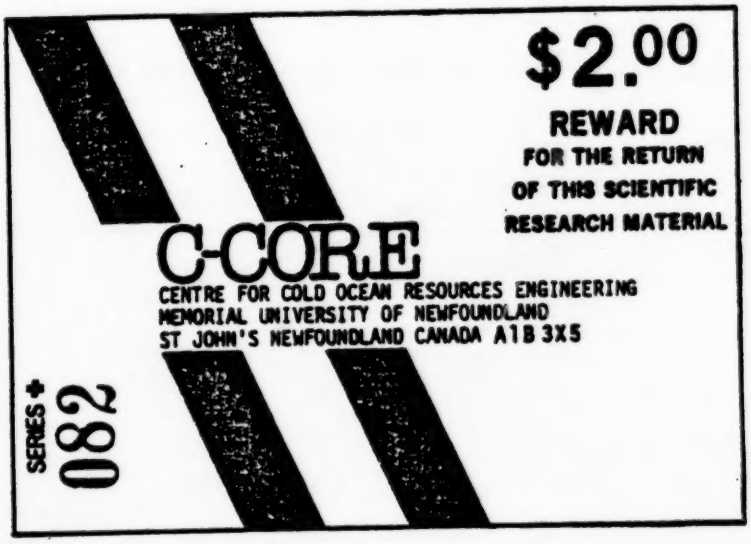
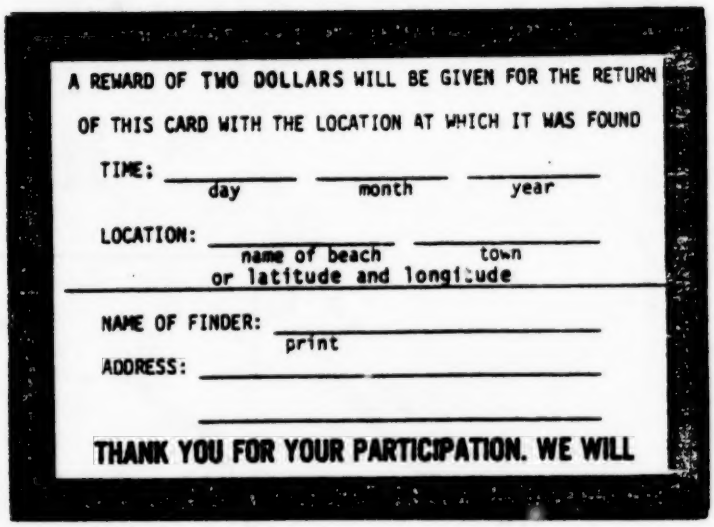


Figure 4. Return locations of cards released in the Beaufort Sea in 1979



SIDE 1


A REWARD OF TWO DOLLARS WILL BE GIVEN FOR THE RETURN
OF THIS CARD WITH THE LOCATION AT WHICH IT WAS FOUND
TIME: day month year
LOCATION: name of beach town
or latitude and longitude
NAME OF FINDER: print
ADDRESS:
THANK YOU FOR YOUR PARTICIPATION. WE WILL

SIDE 2

Figure 5. Drift Card Used In This Study Shown About 4/5 Actual Size

heavily populated coast in the U.K. and Ireland. The anticipated return rates for this experiment in view of the Labrador and Beaufort population levels was in the order of 1% - 2%.

LABRADOR RELEASE RESULTS

The times and locations of Labrador drift card releases is shown in Table 1 and Figure 2. The weather conditions at the time and place of release are indicated in Appendix A. The first card to be returned was found in County Mayo, Ireland, 11 March 1980, 7 months after its release at Flemish Pass. The remaining 1186 were returned during the following 24 months with a peak rate for most release sites around February, 1981. Harvey (1968) found also that for the west British coast return rates of sea surface drifters was highest during February, March and July based on drops made throughout one year. He attributed the high return rate in February and March to the oceanographic conditions that annually prevail during this period where the high July return rate directly reflects the number of people visiting the Coast. Riley and Ramster on the other hand, observe a slightly lower return rate during the summer suggesting that some other factor may have been responsible for the July peak.

Out of all the returns, only 19 were returned from North America. All of these were from release sites north of 58°. The return data are shown in Table 3. Although nearly half of these cards were found in 1981, it is quite possible that they actually came to shore during the previous summer and were not found at that time.

The vast majority of the cards returned were found in Europe, primarily the British Isles and Ireland. The greater number of returns may be partially attributable to the greater population density along the coasts of Europe than on Canadian

Table 3. Return data from cards found along the eastern coast of North America

Release Site	Location Found	Date Found	Lat.	Long.
Davis 1	Winton Bay, Baffin Is.	Aug. 2, 1980	63°24'N	64°40'W
	Chapell Inlet, Baffin Is.	Aug. 9, 1980	62°30'N	65°00'W
	Halls Is., Baffin Is.	July 31, 1981	62°32'N	64°10'W
	Baffin Is.	Aug. 24, 1981	62°07'N	66°03'W
	Lumsden, Nfld.	Jan. 3, 1982	49°17'N	53°36'W
Davis 2	Near Nain, Labrador	June 21, 1980	57°N	62°W
	Near Cape Norman, Nfld.	June, 1981	51°36'N	56°00'W
Davis 3	Indian Tickle, Labrador	June 12, 1980	53°30'N	56°00'W
	Big Brook, Nlfd.	July 6, 1980	51°31'N	56°08'W
Cabot	Deer Cove, Nfld.	Apr. 26, 1980	51°10'N	57°00'W
	House Harbour, Labrador	May 1, 1980	55°58'N	61°30'W
	Bartletts Hr., Nfld.	Aug. 30, 1980	51°30'N	57°00'W
	Adlavik Is., Labrador	Sept. 20, 1980	54°55'N	59°00'W
	Saglek Bay, Labrador	July 7, 1981	58°N	63°W
	Near Nain, Labrador	Aug. 20, 1981	56°30'N	62°W
Karlsefini	Indian Cove, Labrador	May 28, 1980	52°20'N	55°50'W
	Twillingate, Nfld.	July 26, 1980	49°35'N	54°47'W
	Nr. Batteau, Labrador	Aug. 29, 1981	53°25'N	53°50'W
	Big Brook, Nfld.	Oct. 17, 1981	51°31'N	56°08'W

shores, however, in spite of this, several significant observations can be made on the return pattern. First, as already mentioned, all North American returns were from the northern release sites. Second, none of these travelled further south than Newfoundland as might have been expected from the accepted path of the Labrador current. Third, similar drifter studies conducted in the eastern Atlantic region with releases not further than 100 miles from the coast of Ireland or Britain

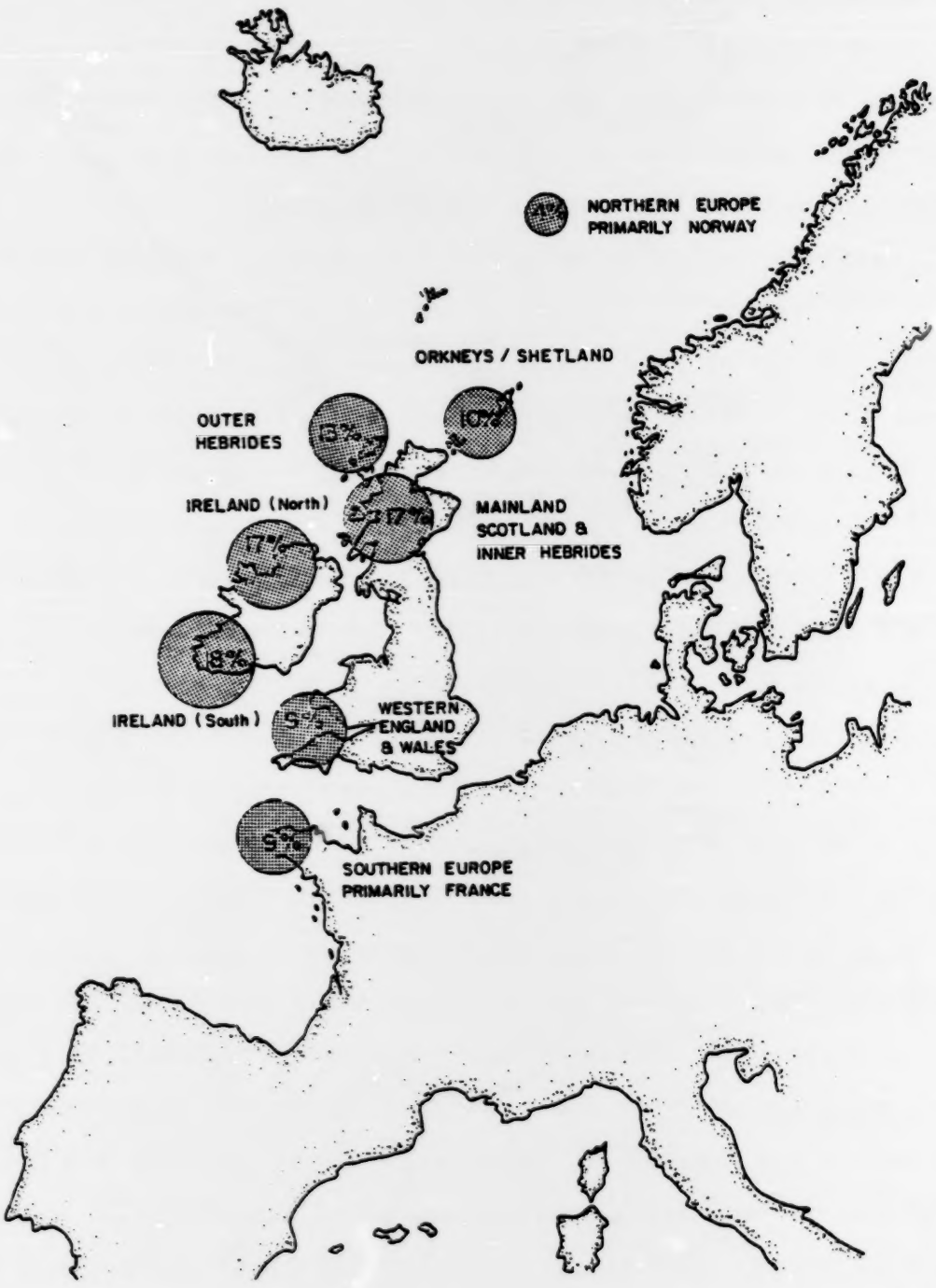


Figure 6. Distribution of European returns from Newfoundland and Labrador releases of 1979. Total cards returned 1186 of 5600.

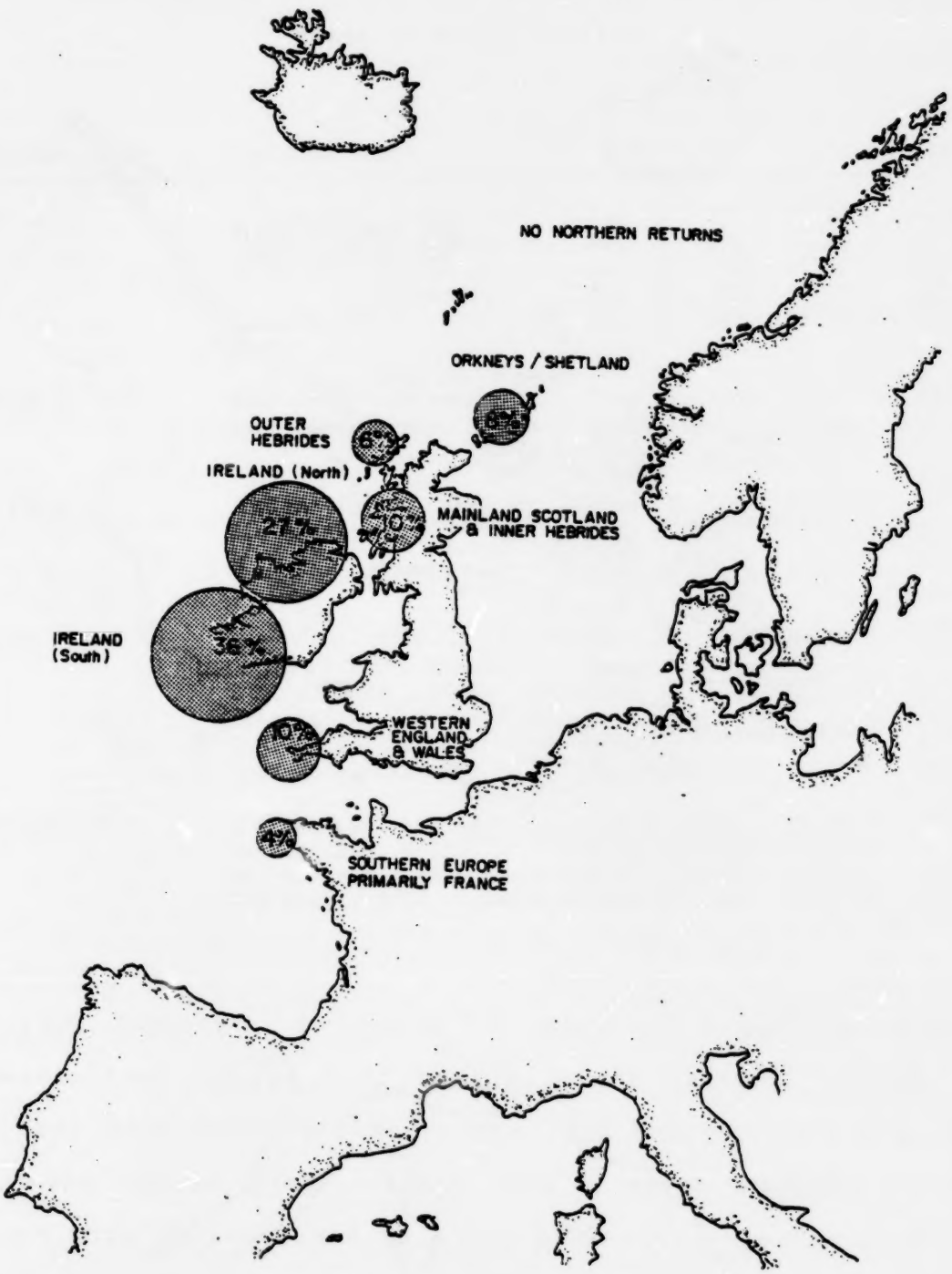


Figure 7. Distribution of returns from the Hibernia release of 1980. Total cards returned 376 of 3000.

seldom result in return rates of greater than 40%, with the mode being roughly 30%. (Cunningham,1981; Harvey,1968; and Hughes,1956). Our European return rates range from 12% to nearly 30%. Taking a 30% or 40% return rate as indicating the presence of 100% of the cards in European waters, and further considering the far greater distance our Labrador cards had to travel, the statistics suggest that most, if not all, of the cards from our more southerly release sites were swept east in the Gulf Stream., Figures 6 and 8 show the distribution of returns from Europe. Table 4 shows the return pattern with time for each of the release sites. While the cards were released over an 8 week period, it is worth noting that the return patterns were very similar for all releases. It is further worth noting that the two lowest return rates were in the release area north of 58°, the same areas which produced the North American landfalls.

There are two possible interpretations for this latter observation. Cards from the northern Labrador and Davis Strait releases would have a statistically higher chance of encountering a weather system which would bring them ashore if it is assumed that the drift trajectory was, on the average, parallel to the coast of Labrador and northern Newfoundland. Alternatively it is possible that the prevailing wind and current patterns in the northern regions favour the entry of cards into a nearshore current which sweeps along the Labrador coast and into the Strait of Belle Isle. Both the distribution of returned cards and the existing reports on surface current patterns near Hudson Strait (Smith, et.al., 1937; Collin & Dunbar, 1964) would favour this

latter hypothesis. Wind and weather patterns were examined for a week following the northerly releases (Appendix A). There was no evidence of persistent or exceptional easterly wind events.

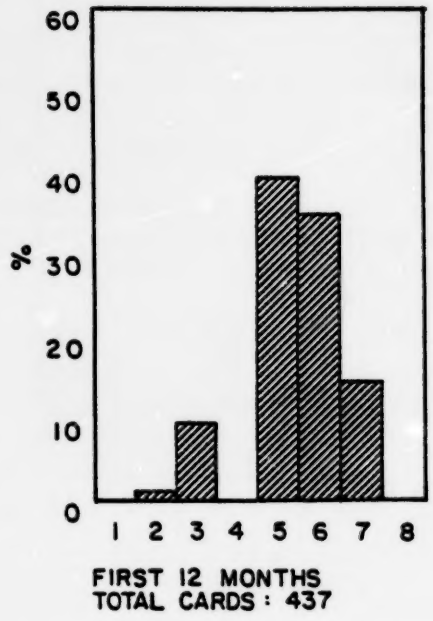
GRAND BANK (HIBERNIA) RELEASE RESULTS

The 3000 cards released at the Hibernia site were all released within 48 hours and 40 km. of one another (Table 1 & Figure 2). None were returned from North America. The first landfall, from Ireland, was found 6 months after its release, and by 9 months after release between 1.1% and 3.5% of the cards had been found and returned. This is widely at variance with the Labrador releases in which only one of the 13 releases yielded more than one return in the first 9 months and most had produced none at all.

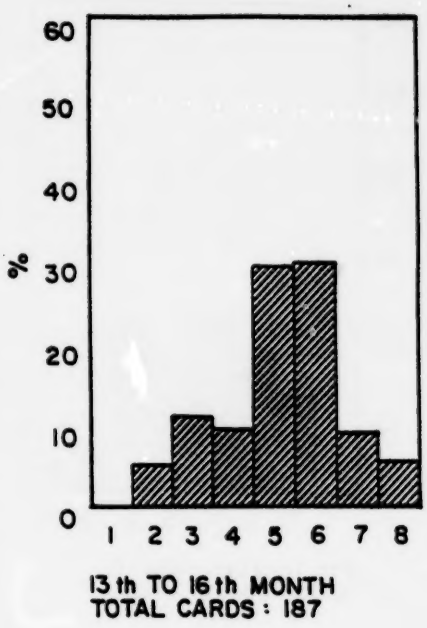
The geographic return pattern of the Hibernia cards was similar to that of the Labrador releases in that initial landfall was in Ireland with a subsequent fanning out to areas north and south of this. However it may be significant that the early Hibernia returns were almost exclusively from Ireland, more than 95% in the first 9 months, while the Labrador returns, while predominantly from Ireland were distributed through other areas as well (Figures 7 & 8). In addition, there have been no returns of Hibernia cards from northern Europe (Norway, Denmark, Iceland, etc.) up to 21 months after release.

Figure 8. Geographic return distribution of returns from the Newfoundland & Labrador releases of 1979 (Figure 8a) and the Hibernia releases of 1980 (Figure 8b) during the time periods indicated in months elasped after each release. Data are expressed as percentages of total cards found during each period.

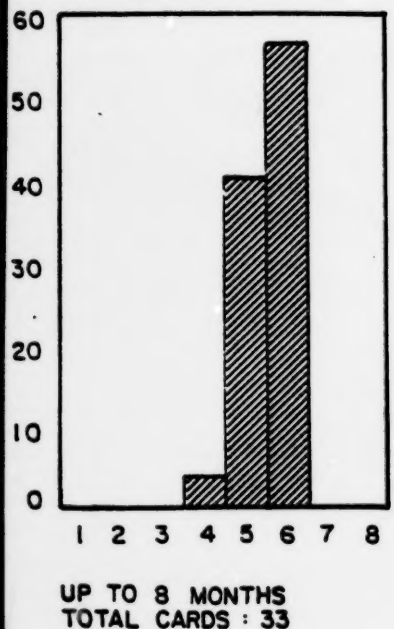
Figure 8a. Newfoundland and Labrador series



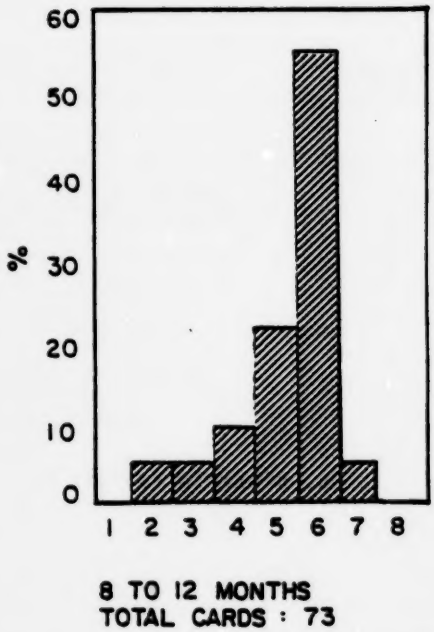
FIRST 12 MONTHS
TOTAL CARDS : 437



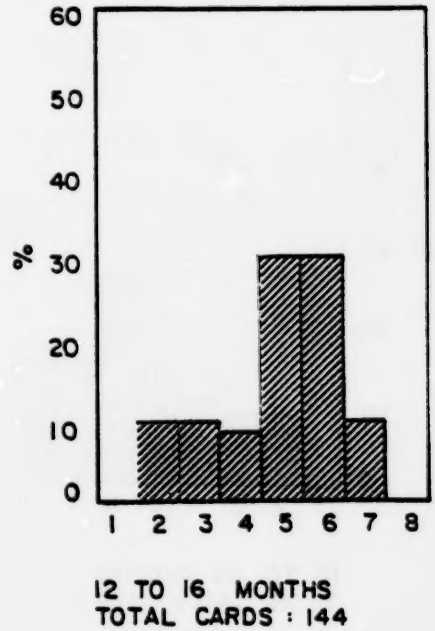
13 th TO 16 th MONTH
TOTAL CARDS : 187



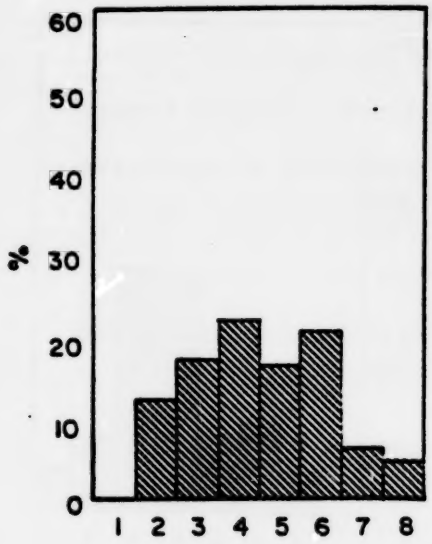
UP TO 8 MONTHS
TOTAL CARDS : 33



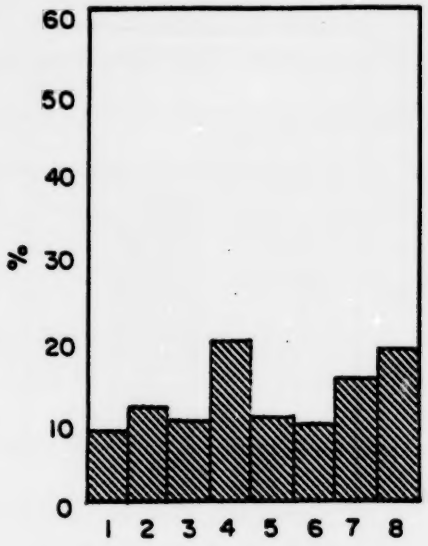
8 TO 12 MONTHS
TOTAL CARDS : 73



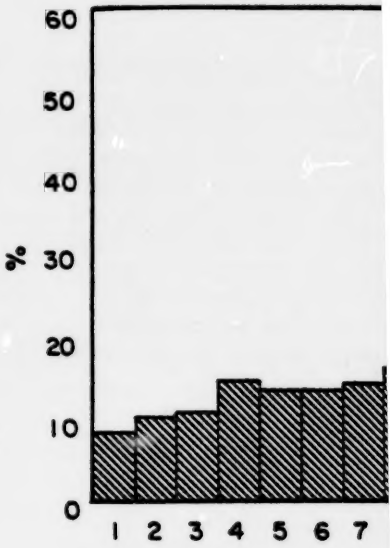
12 TO 16 MONTHS
TOTAL CARDS : 144



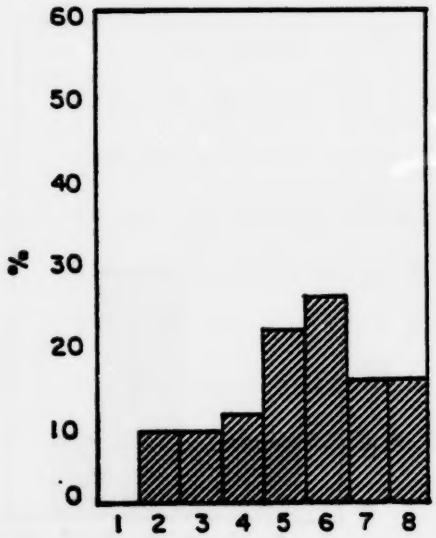
17th TO 20th MONTH
TOTAL CARDS : 466



21st TO 24th MONTH
TOTAL CARDS : 284



29th TO 30th MONTH
TOTAL CARDS : 54



16 TO 20 MONTHS
TOTAL CARDS : 119

8b. Hibernia series

Table 4

Percentage of total returns from the Newfoundland and Labrador releases received in each month starting 8 months after release

	UP TO OCT. 80	OCT. 80 FEB. 81	FEB. 81 TO JUNE 81	JUNE 81 TO OCT. 81	OVERALL
North	0	1%	5	8	3%
Okney/shetland	2%	11%	13	12	11%
Outer Hebrides	12%	17%	12	10	14
Scotland	7%	17%	20	17	17
Ireland N.	40%	23%	14	7	19
Ireland S.	23%	20%	16	9	17
W. England	8%	7%	10	18	10
Europe S.	0	4%	9	16	7
NAM	8%	0	.05	3	2
Total Cards ORKNEY/SHETLAND	141	379	329	179	1028

There were individual differences between the three releases at the Hibernia site which suggest considerable variability in the area over short distances and time periods. First, the returns from site C were more than 35% higher than from A or B, and, second, the fanning out process in C began almost immediately, within 8 months after release, while in the other two a year passed before a significant lateral spread of returns developed. This trend is clearly demonstrated in Appendix B(ii).

BEAUFORT SEA RELEASE RESULTS

The returns from the Beaufort releases were unexceptional in that the observed trajectories conform to the anticipated general westerly flow along the north coast and that the number of returns is roughly what one could expect for an unpopulated coast (1.7%).

Six hundred and thirty cards were released at 6 sites in the Mackenzie Delta area of the Beaufort Sea in September 1979. The location of these sites is shown in Figures 3 and 4 and the date and number of cards released is shown in Table 2 with numbers of cards returned indicated. Of the thirteen cards returned, 10 were found along the north and northwest coasts of Alaska, Yukon and the North West Territories. However, one, from site B was returned from The Commander Islands in the Russian Aleutian Islands, and two others, from Site A, from Campbell River, B.C. and San Diego, California respectively. Return locations are shown in Figure 4.

CONCLUSIONS

LABRADOR The probability of an oilspill along the east coast of Canada actually making landfall along some part of the Canadian Coastline appears to increase with latitude (Figure 9). Probabilities appear to be vanishingly small for the permit areas around Funk Island Bank and Grand Bank but increase to a finite value (which cannot be properly estimated) over Saglek Bank and north.

BEAUFORT

Longshore westerly currents are indicated by the trajectories. There is some evidence of southerly transport through the Bering Strait, possibly via pack ice from the Chukchi Sea which is reported to break out through the Bering Strait once or twice a year (Pease, 1980)

An oilspill in this region would almost certainly result in at least some of the oil coming to shore.

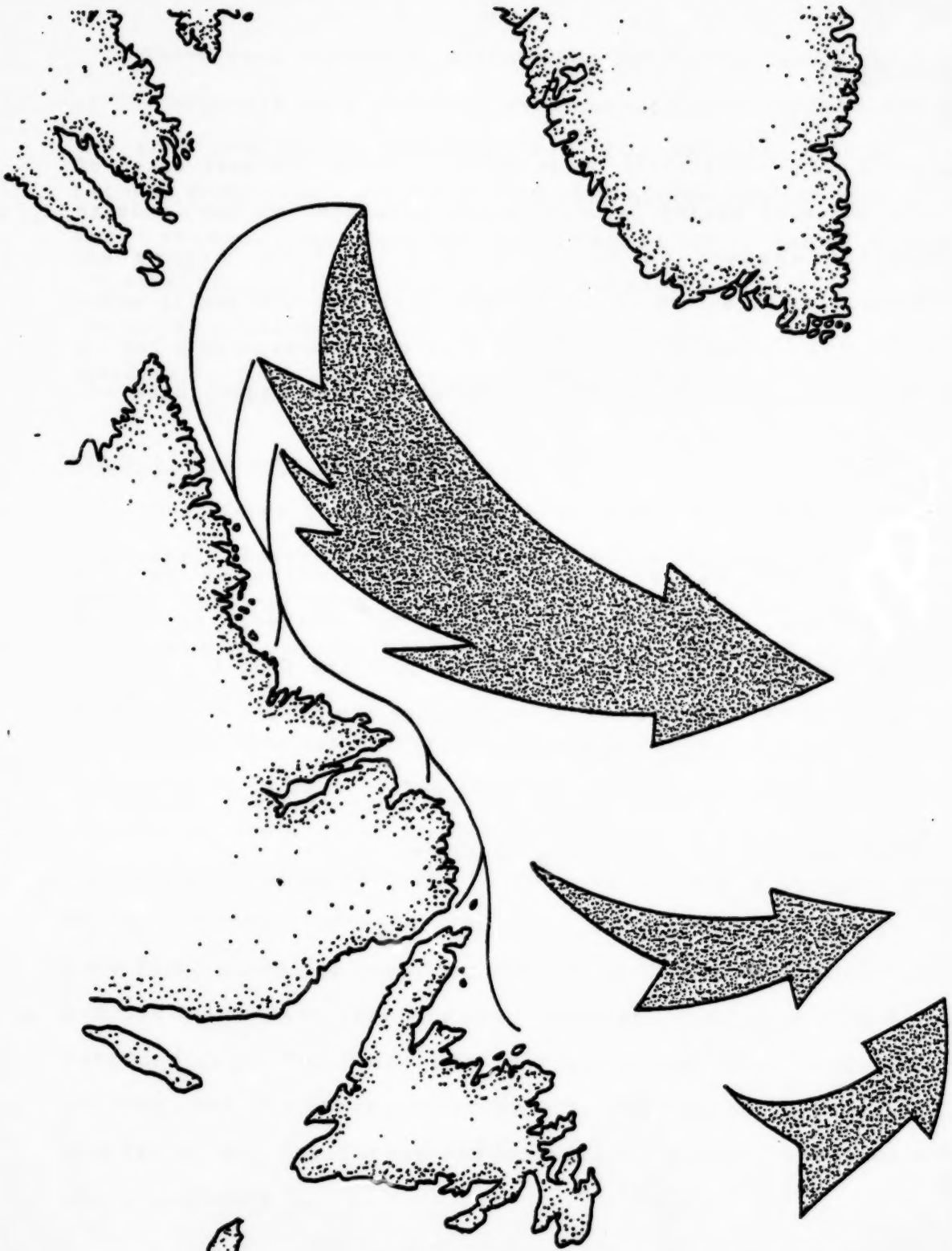


Figure 9. Inferred Surface Circulation For 1979/1980 Drift Card Relea

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APPENDIX A

Weather Conditions

Davis I - 24 August 1979

On the day of release, winds were from the north and fairly strong (ca. 30 knots) but died down by midnight. After a day of negligible wind, the direction shifted to southerly and the next 5 days this trend held with windspeeds ranging from very light to 35 knots.

Davis 2 - 31 August 1979

For a week following this release winds varied between east and south, with a range from 20 - 40 knots.

Davis 3 - 19 September 1979

Winds varying from north to west at speeds varying from 10 to 30 knots.

Cabot - 19 August 1979

Winds no stronger than 20 knots for the week following release. Direction very variable.

Karlsefini - 20 August

Same as Cabot

Snorri - 22 August

Same as Cabot

Bjarni - 15 August

Same as Cabot - primary wind influence generally westerly

Verrazano - 27 August

One day of 20 - 30 knot SSE wind, otherwise light and variable in both direction and speed.

Funk I - 27 August

One day of winds SSE 20 - 35 knots, otherwise variable direction and no greater than 20 knots.

Funk 2 - 10 September

40 knot winds from, NW and S for 3 ca. 12 hour periods. Otherwise light and variable. It was noted at the time of release that a strong and unusual surface current, approximately 1 - 1.5 knots, was running toward the west.

Funk 3 - 24 September

Principal wind influence from NW, speeds 20 - 30 knots for 3 to 4 days.

Flemish 1 - 28 July

2 days of 20 - 30 knots winds from W & SW followed by 4 days of light and variable.

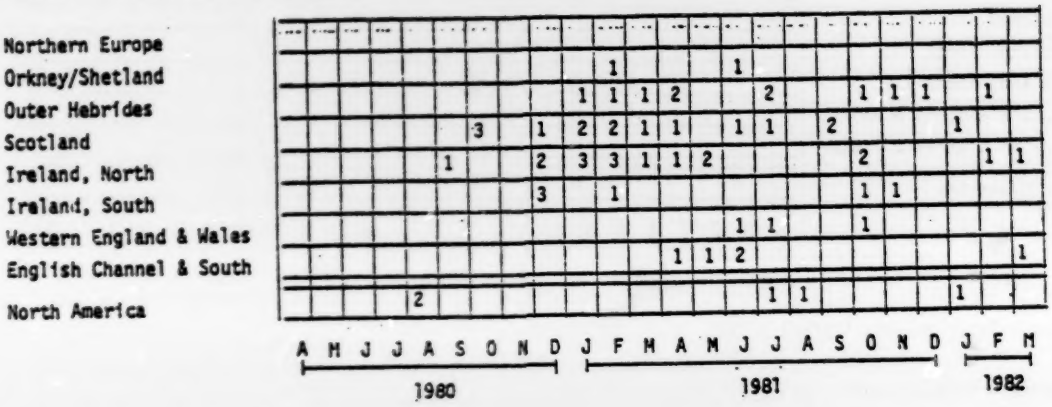
Flemish 2 - 4 August

Wind mostly steady from the SW up to 20 knots

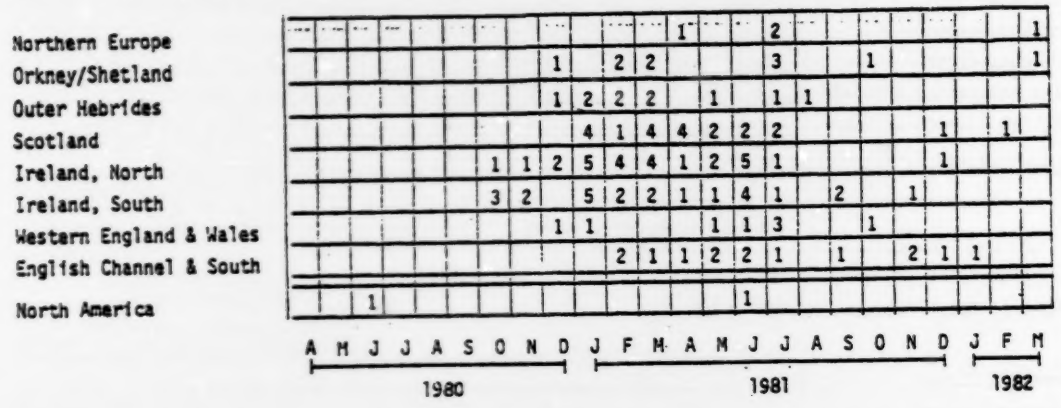
APPENDIX B(i)

Return data from Newfoundland/Labrador drift card releases

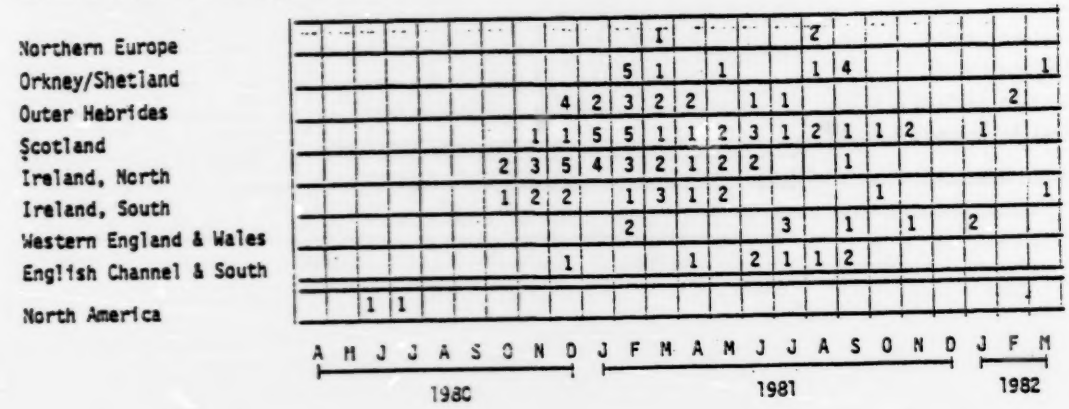
DAVIS 1 Total returns 64 = 13%



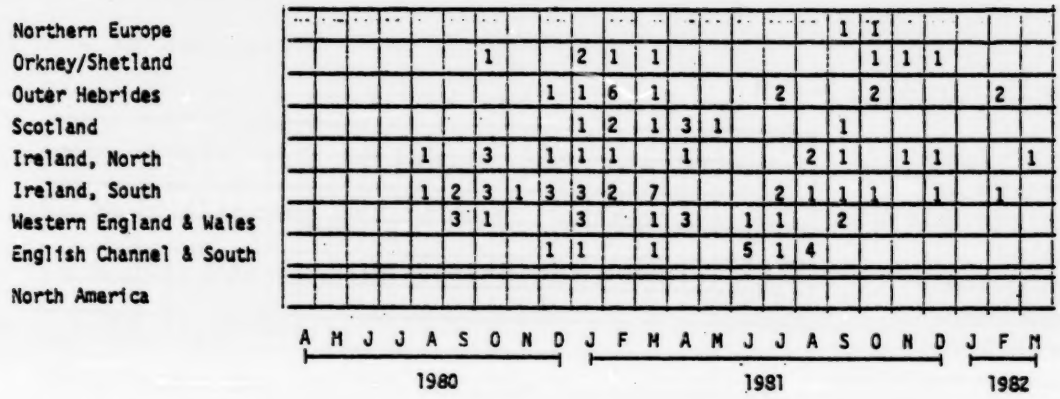
DAVIS 2 Total returns 120/500 = 24%



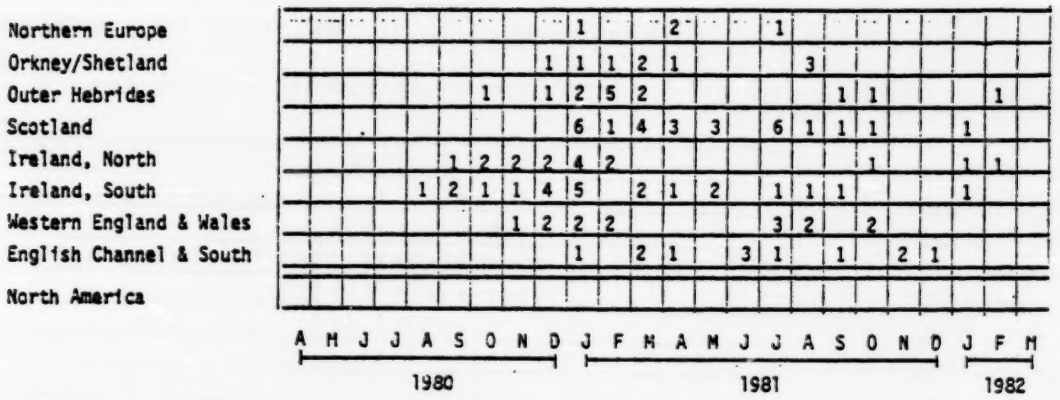
DAVIS 3 Total returns 118/500 = 24%



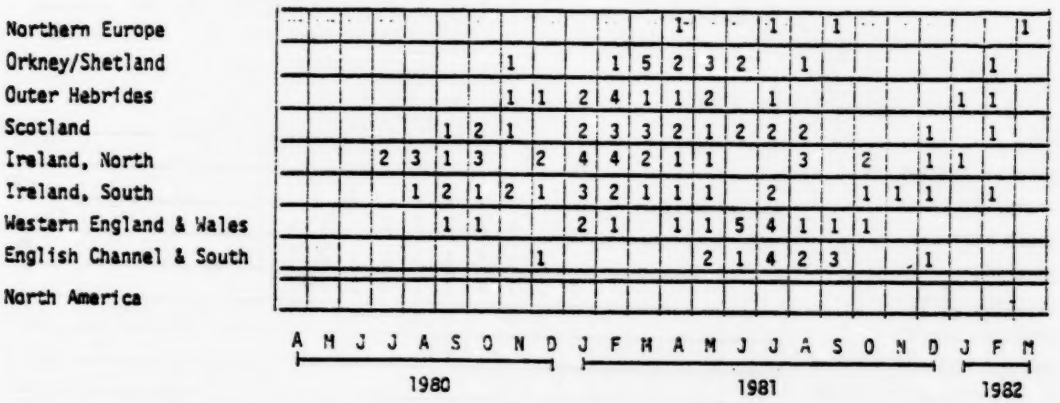
FUNK 1 Total returns 105/500 = 21%



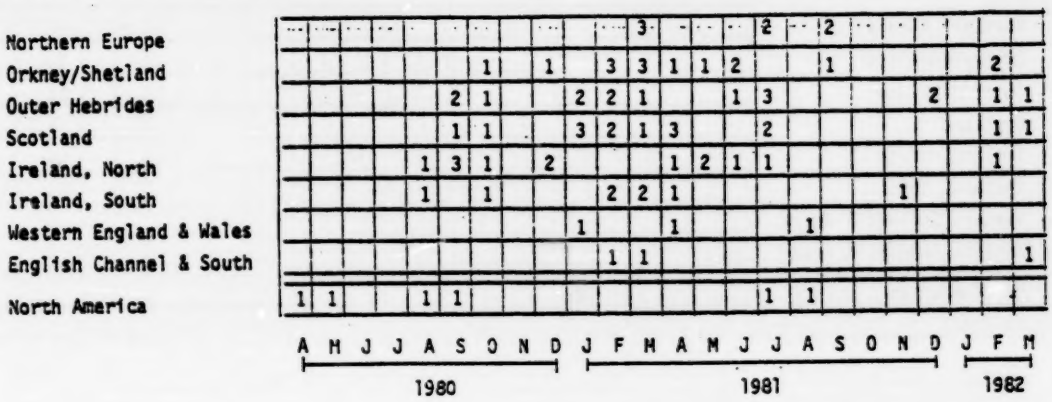
FUNK 2 Total returns 119/500 = 24%



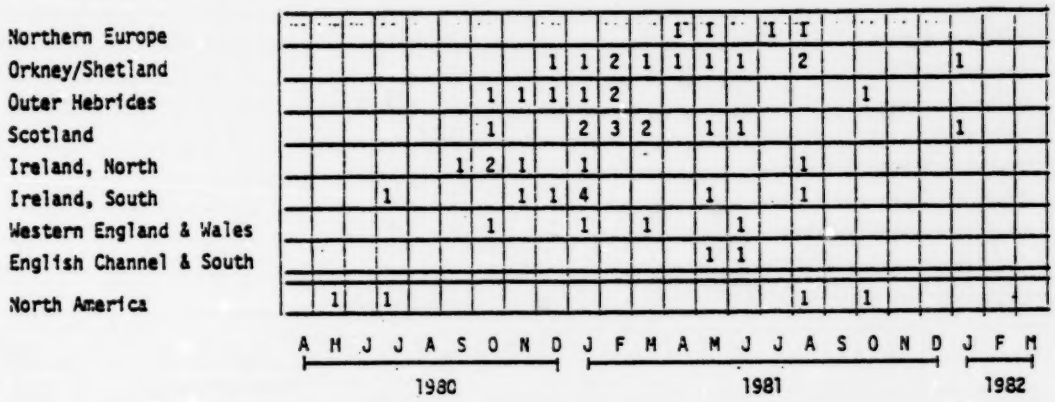
FUNK 3 Total returns 141/500 = 28%



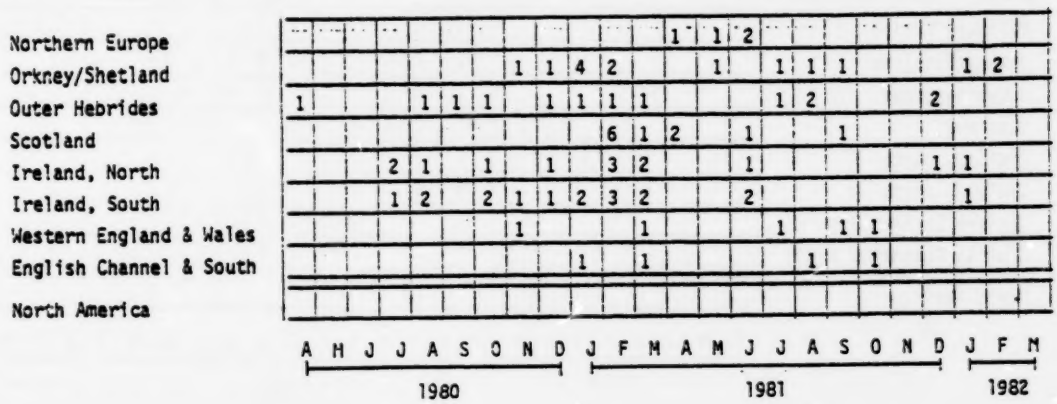
CABOT Total returns 86/500 = 17%



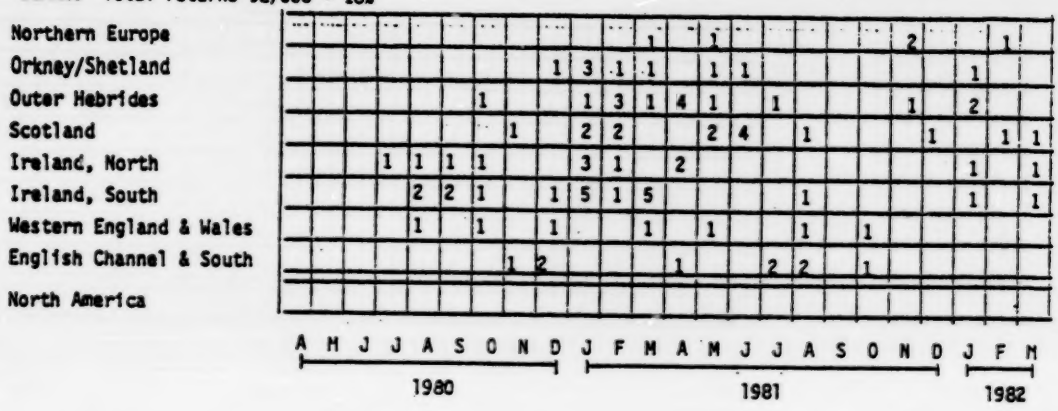
KARLSEFINI Total returns 58/500 = 12%



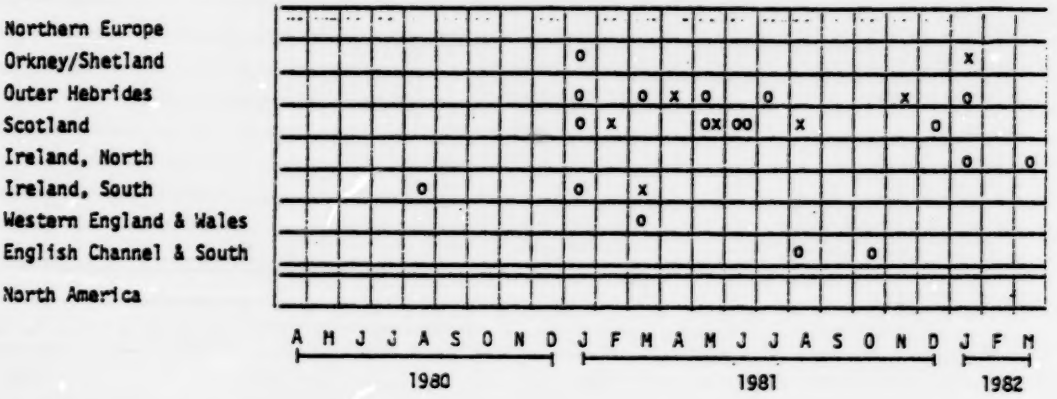
SNORRI Total returns 82/500 = 16%



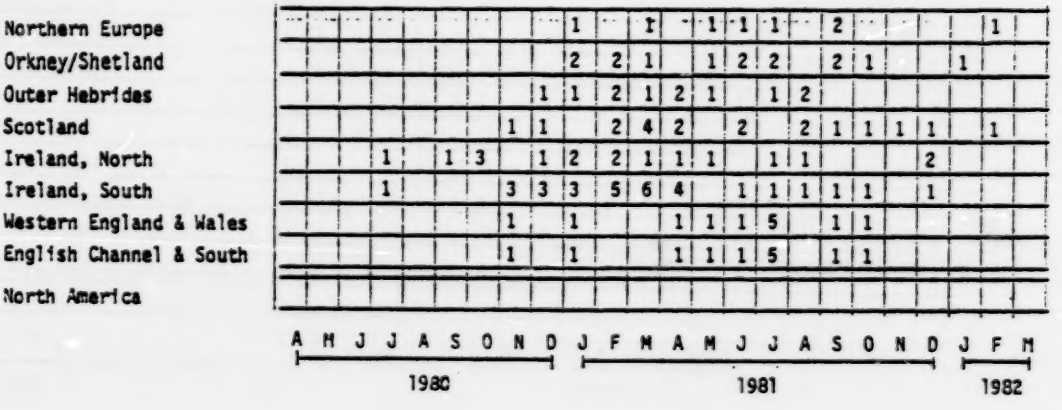
BJARNI Total returns 92/500 = 18%



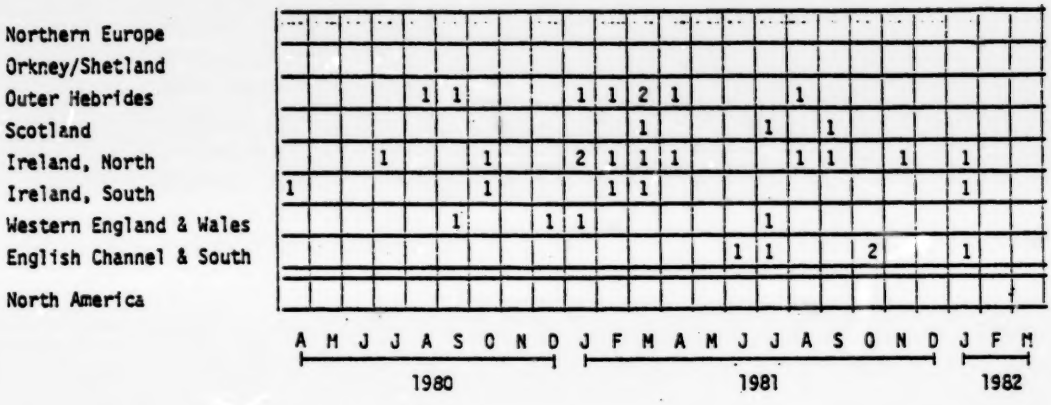
BJARNI Series #5 x - weighted cards, 7 returns = 14%
o - unweighted cards, 18 returns = 36%



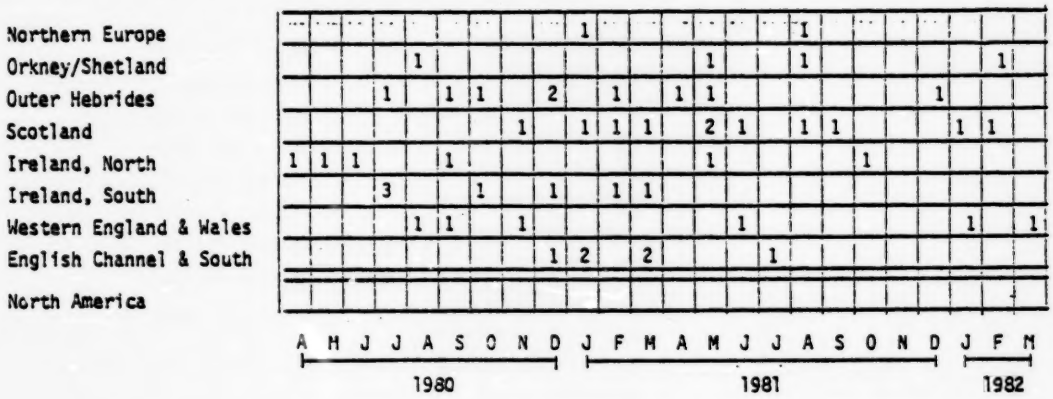
VERRAZANO Total returns 122/500 = 24%



FLEMISH 1 Total returns 36/200 = 18%



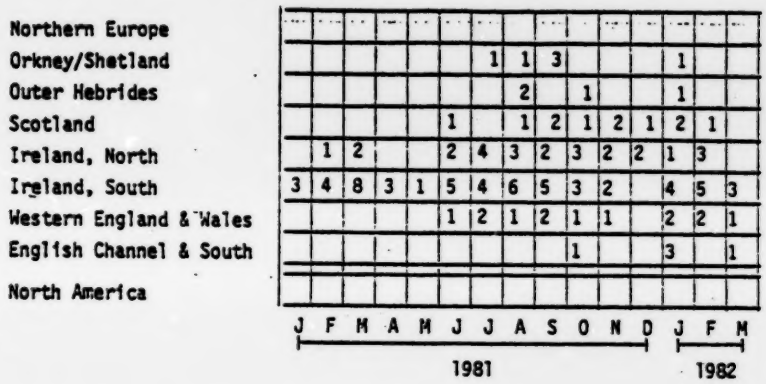
FLEMISH 2 Total returns 51/200 = 26%



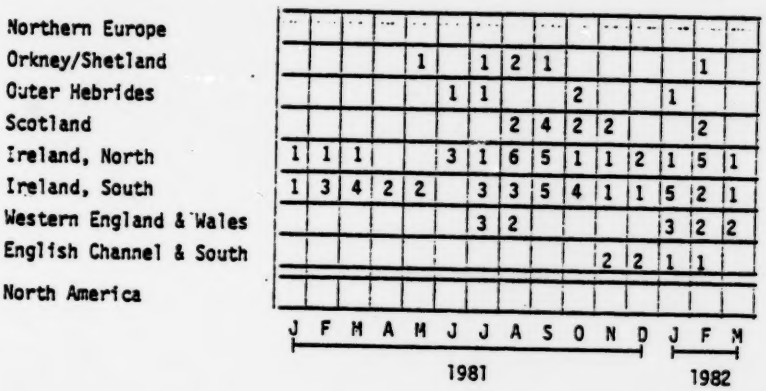
APPENDIX B(ii)

Return data from Hibernia drift card releases

HIBERNIA A Total returns 116/1000 = 12%



HIBERNIA B Total returns 107/1000 = 11%



HIBERNIA C Total returns 153/1000 = 15%